Listing of Claims

1. (Currently Amended) A method of heat treating a 718-type nickel-base alloy comprising:

pre-solution treating the nickel-base alloy wherein an amount of at least one grain boundary precipitate selected from the group consisting of δ-phase precipitates and η-phase precipitates is formed within the nickel-base alloy, the at least one grain boundary precipitate having a short, generally rod-shaped morphology;

solution treating the nickel-base alloy wherein substantially all γ'-phase precipitates and γ"-phase precipitates in the nickel-base alloy are dissolved while at least a portion of the amount of the at least one grain boundary precipitate is retained;

cooling the nickel-base alloy after solution treating the nickel-base alloy at a first cooling rate sufficient to suppress formation of γ'-phase and γ"-phase precipitates in the nickel-base alloy;

aging the nickel-base alloy in a first aging treatment wherein primary precipitates of γ'-phase and γ"-phase are formed in the nickel-base alloy; and

aging the nickel-base alloy in a second aging treatment wherein secondary precipitates of γ'-phase and γ"-phase are formed in the nickel-base alloy, the secondary precipitates being finer than the primary precipitates; and

wherein after heat treating the nickel-base alloy, the γ'-phase precipitates are predominant strengthening precipitates in the nickel-base alloy and a majority of the grain boundaries of the nickel-base alloy are pinned by at least one grain boundary precipitate.

2. (Cancelled)

3. (Original) The method of claim 1 wherein the nickel-base alloy comprises, in percent by weight, up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, up to 14 iron, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum

of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3.

4. (Original) The method of claim 1 wherein pre-solution treating the nickel-base alloy comprises heating the nickel-base alloy at a temperature ranging from 1500°F to 1650°F for a time ranging from 2 hours to 16 hours

5. (Original) The method of claim 1 wherein pre-solution treating the nickel-base alloy comprises heating the nickel-base alloy at a temperature ranging from 1550°F to 1600°F for a time ranging from 2 hours to 16 hours.

6. (Original) The method of claim 1 wherein solution treating the nickel-base alloy comprises heating the nickel-base alloy at a temperature ranging from 1725°F to 1850°F for no greater than 4 hours.

7. (Original) The method of claim 1 wherein solution treating the nickel-base alloy comprises heating the nickel-base alloy at a temperature ranging from 1750°F to 1800°F for no greater than 2 hours.

8. (Original) The method of claim 1 wherein the first cooling rate is at least 800°F per hour.

9. (Original) The method of claim 1 wherein cooling the nickel-base alloy after solution treating comprises cooling the nickel-base alloy to 1000°F or less.

10. (Original) The method of claim 1 wherein the first aging treatment comprises heating the nickel-base alloy at a temperature ranging from 1325°F to 1450°F for a time ranging from 2 hours to 8 hours.

11. (Original) The method of claim 1 wherein the first aging treatment comprises heating the nickel-base alloy at a temperature ranging from 1365°F to 1450°F for a time ranging from 2 hours to 8 hours.

12. (Original) The method of claim 1 wherein the second aging treatment comprises heating the nickel-base alloy at a temperature ranging from 1150°F to 1300°F for at least 8 hours.

13. (Original) The method of claim 1 wherein the second aging treatment comprises heating the nickel-base alloy at a temperature ranging from 1150°F to 1200°F for at least 8 hours.

14. (Cancelled)

15. (Original) The method of claim 1 wherein after heat treating the nickel-base alloy, the nickel-base alloy has a yield strength at 1300°F of at least 120 ksi, a percent elongation at 1300°F of at least 12 percent, a notched stress-rupture life of at least 300 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

16. (Original) The method of claim 1 further comprising cooling the nickel-base alloy to 1000°F or less after pre-solution treating and prior to solution treating the nickel-base alloy.

17. (Original) The method of claim 1 further comprising cooling the nickel-base alloy after the first aging treatment to a second aging temperature at a cooling rate ranging from 50°F per hour to 100°F per hour.

18. (Original) A method of heat treating a 718-type nickel-base alloy, the nickel-base alloy including up to 14 weight percent iron, the method comprising:

pre-solution treating the nickel-base alloy at a temperature ranging from 1500°F to 1650°F for a time ranging from 2 to 16 hours;

solution treating the nickel-base alloy for no greater than 4 hours at a solution temperature ranging from 1725°F to 1850°F;

cooling the nickel-base alloy at a first cooling rate of at least 800°F per hour after solution treating the nickel-base alloy;

aging the nickel-base alloy in a first aging treatment for no greater than 8 hours at a temperature ranging from 1325°F to 1450°F; and aging the nickel-base alloy in a second aging treatment for at least 8 hours at a second aging temperature, the second aging temperature ranging from 1150°F to 1300°F.

19. (Original) The method of claim 18 wherein the nickel-base alloy further includes up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3

20. (Original) The method of claim 18 wherein after pre-solution treating the nickel-base alloy, the nickel-base alloy is cooled to 1000°F or less prior to solution treating the nickel-base alloy.

21. (Original) The method of claim 18 wherein after pre-solution treating the nickel-base alloy the nickel-base alloy is directly heated to the solution temperature.

22. (Original) The method of claim 18 wherein solution treating the nickel-base alloy comprises heating the nickel-base alloy for no greater than 2 hours at a solution temperature ranging from 1750°F to 1800°F.

23. (Original) The method of claim 18 wherein the first aging treatment comprises heating the nickel-base alloy for 2 to 8 hours a temperature ranging from 1365°F to about 1450°F.

24. (Original) The method of claim 18 wherein after heat treating, the nickel-base alloy has a yield strength at 1300°F of at least 120 ksi, a percent elongation at 1300°F of at least 12 percent, a notched stress-rupture life of at least 300 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

25. (Currently Amended) The method of claim 18 wherein after heat treating the nickel-base

alloy, the nickel-base alloy comprises:

γ'-phase precipitates and γ"-phase precipitates, wherein the γ'-phase precipitates are predominant strengthening precipitates in the nickel-base alloy; and

an amount of ~~at least one~~ grain boundary ~~precipitate~~precipitates sufficient to pin the majority of the grain boundaries in the matrix, the grain boundary precipitates being selected from the group consisting of δ-phase precipitates ~~and~~, η-phase precipitates, ~~wherein the at least one grain boundary precipitate has a~~and mixtures thereof, and having short, generally rod-shaped ~~morphology~~morphologies.

26. (Original) A method of heat treating a nickel-base alloy, the nickel-base alloy comprising, in weight percent, up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, up to 14 iron, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3, the method comprising:

solution treating the nickel-base alloy for no greater than 4 hours at a solution temperature ranging from 1725°F to 1850°F;

cooling the nickel-base alloy at a first cooling rate after solution treating the nickel-base alloy;

aging the solution treated nickel-base in a first aging treatment for no greater than 8 hours at a temperature ranging from 1365°F to 1450°F; and

aging the nickel-base alloy in a second aging treatment for at least 8 hours at a second aging temperature, the second aging temperature ranging from 1150°F to 1300°F.

27. (Original) The method of claim 26 wherein solution treating the nickel-base alloy comprises heating the nickel-base alloy for no greater than 2 hours at a solution temperature ranging from 1750°F to 1800°F.

28. (Original) The method of claim 26 wherein the first cooling rate is at least 800°F per hour.

29. (Original) The method of claim 26 wherein aging the nickel-base alloy in a second aging treatment comprises heating the nickel-base alloy at a second aging temperature ranging from 1150°F to 1200°F.

30. (Original) The method of claim 26 wherein after heat treating, the nickel-base alloy has a yield strength at 1300°F of at least 120 ksi, a percent elongation at 1300°F of at least 12 percent, a notched stress-rupture life of at least 300 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

31. (Original) The method of claim 26 further comprising pre-solution treating the nickel-base alloy at a temperature ranging from 1500°F to 1650°F for a time period ranging from 2 to 16 hours prior to solution treating the nickel-base alloy.

32. (Currently Amended) The method of claim 31 wherein after heat treating the nickel-base alloy, the nickel-base alloy comprises:

γ'-phase precipitates and γ"-phase precipitates, wherein the γ'-phase precipitates are predominant strengthening precipitates in the nickel-base alloy; and

an amount of ~~at least one~~ grain boundary ~~precipitate~~precipitates sufficient to pin the majority of the grain boundaries in the matrix, the grain boundary precipitates being selected from the group consisting of δ-phase precipitates~~and~~, η-phase precipitates, ~~wherein the at least one grain boundary precipitates has a~~and mixtures thereof, and having short, generally rod-shaped ~~morphology~~morphologies.

33. (Currently Amended) A 718-type nickel-base alloy comprising:

a matrix comprising γ'-phase precipitates and γ"-phase precipitates, wherein the γ'-phase precipitates are predominant strengthening precipitates in the nickel-base alloy; and

an amount of ~~a at least one~~ grain boundary ~~precipitate~~precipitates sufficient to pin the majority of the grain boundaries in the matrix, the grain boundary precipitates being selected from the group consisting of δ-phase precipitates~~and~~, η-phase precipitates,

~~wherein the at least one grain boundary precipitates has a~~and mixtures thereof, and having short, generally rod-shaped ~~morphology~~morphologies; and

wherein the nickel-base alloy ~~has a yield strength at 1300°F of at least 120 ksi, a percent elongation at 1300°F of at least 12 percent, a notched stress-rupture life of at least 300 hours as measured at 1300°F and 80 ksi, and a low notch sensitivity~~ includes, in percent by weight, up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, up to 14 iron, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3.

34-35 (Cancelled)

36. (Currently Amended) A heat treated 718-type nickel-base alloy including up to 14 weight percent iron and comprising a matrix comprising γ'-phase precipitates and γ"-phase precipitates, wherein the γ'-phase precipitates are ~~the~~ predominant strengthening precipitates in the nickel-base alloy, and an amount of ~~at least one~~ grain boundary ~~precipitate~~precipitates sufficient to pin the majority of the grain boundaries in the matrix, the grain boundary precipitates being selected from the group consisting of δ-phase precipitates ~~and~~, η-phase precipitates, ~~wherein the at least one grain boundary precipitate has a~~and mixtures thereof, and having short, generally rod-shaped ~~morphology, and~~morphologies, wherein the nickel-base alloy is heat treated by:

pre-solution treating the nickel-base alloy at a temperature ranging from 1500°F to 1650°F for a time ranging from 2 to 16 hours;

solution treating the nickel-base alloy ~~alloy~~ for no greater than 4 hours at a solution temperature ranging from 1725°F to 1850°F,

cooling the nickel-base alloy at a first cooling rate of at least 800°F per hour after solution treating the nickel-base alloy;

aging the nickel-base alloy in a first aging treatment from 2 hours to 8 hours at a temperature ranging from 1325°F to 1450°F; and

aging the nickel-base alloy in a second aging treatment for at least 8 hours at a second aging temperature, the second aging temperature ranging from 1150°F to 1300°F.

37. (Currently Amended)) An article of manufacture comprising a 718-type nickel-base alloy, the nickel-base alloy comprising:

a matrix comprising γ'-phase precipitates and γ"-phase precipitates, wherein the γ'-phase precipitates are predominant strengthening precipitates in the nickel-base alloy; and

an amount of ~~at least one~~ grain boundary ~~precipitate~~precipitates sufficient to pin the majority of the grain boundaries in the matrix, the grain boundary precipitates being selected from the group consisting of δ-phase precipitates~~ and~~, η-phase precipitates, ~~wherein the at least one grain boundary precipitates has a~~and mixtures thereof, and having short, generally rod-shaped ~~morphology~~morphologies; and

wherein the nickel-base alloy ~~has a yield strength at 1300°F of at least 120 ksi, a percent elongation at 1300°F of at least 12 percent, a notched stress-rupture life of at least 300 hours as measured at 1300°F and 80 ksi, and a low notch sensitivity~~ includes, in percent by weight, up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, up to 14 iron, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3.

38. (Cancelled)

39. (Original) The article of manufacture of claim 37 wherein the article of manufacture is selected from the group consisting of a turbine or compressor disk, a blade, a case, a shaft, and a fastener.

40. (Original) A method of forming an article of manufacture comprising a 718-type nickel-base alloy including up to 14 weight percent iron, the method comprising:

forming the nickel-base alloy into a desired configuration; and

heat treating the nickel-base alloy, wherein heat treating the nickel-base alloy comprises:

pre-solution treating the nickel-base alloy at a temperature ranging from 1500°F to 1650°F for a time ranging from 2 to 16 hours;

solution treating the nickel-base alloy for no greater than 4 hours at a solution temperature ranging from 1725°F to 1850°F;

cooling the nickel-base alloy at a first cooling rate of at least 800°F per hour after solution treating the nickel-base alloy;

aging the nickel-base alloy in a first aging treatment from 2 hours to 8 hours at a temperature ranging from 1325°F to 1450°F; and

aging the nickel-base alloy in a second aging treatment for at least 8 hours at a second aging temperature, the second aging temperature ranging from 1150°F to 1300°F.

41. (Original) The method of claim 40 wherein the nickel-base alloy comprises, in percent by weight, up to 0.1 carbon, from 12 to 20 chromium, up to 4 molybdenum, up to 6 tungsten, from 5 to 12 cobalt, up to 14 iron, from 4 to 8 niobium, from 0.6 to 2.6 aluminum, from 0.4 to 1.4 titanium, from 0.003 to 0.03 phosphorus, from 0.003 to 0.015 boron, and nickel; wherein a sum of the weight percent of molybdenum and the weight percent of tungsten is at least 2 and not more than 8, and wherein a sum of atomic percent aluminum and atomic percent titanium is from 2 to 6, a ratio of atomic percent aluminum to atomic percent titanium is at least 1.5, and the sum of atomic percent aluminum and atomic percent titanium divided by atomic percent niobium is from 0.8 to 1.3.

42. (New) The nickel-base alloy of claim 33 wherein the nickel-base alloy has a notched stress-rupture life of at least 400 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

43. (New) The nickel-base alloy of claim 36 wherein the nickel-base alloy has a notched stress-rupture life of at least 400 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

44. (New) The nickel-base alloy of claim 37 wherein the nickel-base alloy has a notched stress-rupture life of at least 400 hours as measured at 1300°F and 80 ksi, and a low notch-sensitivity.

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